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(6) COMPREHENSION OF TIME-COMPRESSED SPEECH AS A FUNCTION OF TRAINING

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(10) Joseph V. Lambert, Joyce L. Shields, Paul A. Gade, and J. Douglas Dressel

HUMAN FACTORS IN TACTICAL OPERATIONS TECHNICAL AREA

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This experiment studied five training methods for effective listening of time-compressed speech. Army subjects trained by two methods using incentives understood speech played 2.2 times faster than normal without degradation of performance. Subjects trained by three methods not using incentives had significantly degraded performance when compressed speech was presented at rates faster than 1.85 times the normal rate.

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Technical Paper 295

COMPREHENSION OF TIME-COMPRESSED SPEECH AS A FUNCTION OF TRAINING

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HUMAN FACTORS IN TACTICAL OPERATIONS TECHNICAL AREA

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FOREWORD

This report is concerned specifically with training people to comprehend compressed speech. Within the Army Research Institute for the Behavioral and Social Sciences (ARI), research in human performance enhancement--locating and expanding the boundaries of sensory perception--is an important facet of the work of the Human Factors in Tactical Operations Technical Area. Although current programs in this Technical Area emphasize research in spatial orientation and visual perception, particularly as applicable to night operations and aircrew performance, the Technical Area also has been concerned with factors affecting auditory perception. An earlier publication from the same program, ARI Technical Research Note 236, compared playback techniques and speech comprehension. Two other publications from this program, ARI Technical Papers 296 and 297, deal with the study of thresholds of intelligibility of compressed speech.

The principles developed in this area of research can be applied in any agency that needs rapid review and analysis of large amounts of auditory material. The project reported here was originally conducted at Fort Devens, Mass., as technology base research under Army Project 2Q762717A723, contributing to HRN 76-38 for the Army Security Agency (now part of the Army Intelligence Command).

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Technical Director (Designate)

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COMPREHENSION OF TIME-COMPRESSED SPEECH AS A FUNCTION OF TRAINING

BRIEF

Requirement:

An important part of the U.S. Army's defensive mission worldwide is the daily reception and processing of a great number of communications, many of them sent by radio and telegraph and taped for later processing. Army communications processors need help in rapidly reviewing, evaluating, and summarizing the taped communications. Recent technological advances have made potentially helpful speech compression devices available at relatively low cost. Such devices play back an audio recording at rates faster than the original recording rate without a change in pitch. If the Army is to use the technology of compressed speech effectively, it is necessary to determine if Army personnel can be trained to listen to verbal material with adequate comprehension when that material is played at rates greater than 1.5 times the normal speed.

Procedure:

Fifty Army enlisted personnel were divided into five groups. Members of each group were trained to listen to compressed speech under one of five different training methods. Two of the training methods used the acquisition of leave time as an incentive; three did not. After training, all groups were tested for comprehension of five different passages of compressed speech. Each group heard the passages presented at five rates: 130 words per minute (wpm), 195 wpm, 241 wpm, 286 wpm, or 332 wpm. The performance of the participants who received training was compared to the performance of a group that listened to all five test passages at normal speed, 130 wpm.

Findings:

Participants who were trained using leave time as an incentive showed significantly better comprehension under highly compressed speech conditions than did participants trained without incentives.

Utilization of Findings:

The results clearly show that the incentive training methods used in this experiment were effective in producing short-term, positive changes in performance. At least for this group of Army participants, merely giving feedback about performance was not sufficient to insure good performance.

Users of the speech compression comprehension training methods may want to employ positive incentives. The positive effects of such training on performance can be expected to persist for at least short periods of time; the long-term effects of incentive training on comprehension of compressed speech, however, need further assessment.

COMPREHENSION OF TIME-COMPRESSED SPEECH AS A FUNCTION OF TRAINING

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COMPREHENSION OF TIME-COMPRESSED SPEECH AS A FUNCTION OF TRAINING

INTRODUCTION

An important part of the U.S. Army's defensive mission worldwide is the daily receiving and processing of a great number of communications, many of which are sent by radio and telegraph and taped for later processing. Army communications processors need help in rapidly reviewing, evaluating, and summarizing these taped communications. Recent technological advances have made potentially helpful speech compression devices available at relatively low cost. Such devices play back an audio recording at rates faster than the original recording rate without a change in pitch.

In the most widely used method of speech compression, a tape recording is played through a device at a speed that is a preselected amount faster than the originally recorded rate. By systematically discarding portions of the speech signal, the device preserves the pitch and sound characteristics of the original tape, thus eliminating the "Donald Duck" effect normally caused by increasing the tape speed. The discard intervals occur in a fixed relationship across time and are completely independent of the contents of the speech signal itself. While no entire speech sound is likely to be lost completely because the interval is generally shorter than any single speech sound, some critical features may at times be deleted. Although pitch-normalized output tends to preserve phrasings, stress, and pauses in the original speech record, increases above twice the normal speed tend to produce some distortions.

The fact that untrained listeners can comprehend compressed speech has been well documented. For example, Foulke (1968) showed that the comprehension scores of college students untrained in listening to compressed speech did not decline significantly until the word rate was increased above 250 words per minute (wpm). Recently, Shields (1975) demonstrated that Army communications processors, untrained in listening to compressed speech, could accurately identify the subject matter of highly technical communications compressed to 1.5 times their normal speed of approximately 100 wpm.

For the Army to make effective use of the technology of compressed speech, it is necessary to determine if Army personnel can be trained to listen to verbal material with adequate comprehension when material is played at rates greater than 1.5 times the normal speed.

In nonmilitary settings, several investigators have reported some success in training people to comprehend time-compressed speech. Grumpelt and Rubin (1968), for example, trained blind high school students in two sessions a day for at least 14 days to listen to time-compressed speech at 275 and 300 wpm. A control group heard the same

material at its normal speed of 175 wpm. The performance of the experimental group was significantly superior to that of the control group in a posttest given at 300 wpm, but both groups showed a significant decline in posttest performance compared with pretest performance.

Harley (1966) reported that the mean comprehension scores of blind high school students increased from 43% (pretest) to 67% (posttest) after 1 month of merely listening to compressed speech at the same rate, 275 wpm, as was used in pre- and posttesting. No appropriate control group, however, was used in this study.

In another experiment (Klineman, 1963), fifth- and sixth-grade braille students listened to material compressed to 300 wpm during six 45-minute periods. Pre- and posttests of material at 300 wpm administered to the students and a comparable control group indicated that the experimental group made significantly greater gains in comprehension than did the control group.

In a study by Orr, Friedman, and Williams (1965), subjects listened to selections presented initially at 325 wpm (175 wpm was the normal rate). The speed was increased in 25-wpm increments over several weeks to a final rate of 475 wpm. Tests for comprehension at this final rate indicated a 210% improvement for the experimental subjects; whereas control subjects showed no such gain over pretest scores. It should be pointed out, however, that subjects in the control group listened to taped material only during test probes. It is conceivable that the differences in performance between experimental and control subjects might have been due to differences in amount of practice in listening to any taped material rather than to differences in practice in listening to time-compressed taped material.

Voor (1962) found a significant improvement in comprehension scores over five trials when he presented college students with five taped stories compressed to 380 wpm (double their original rate). Again, however, appropriate control groups were omitted.

On the other hand, not all investigators have found a significant gain in listening comprehension as a function of training sessions using compressed speech. For example, Foulke (1964) presented blind children with more than 25 hours of speech at 350 wpm, and tested the children for comprehension at this rate before and after training. Using equivalent forms of the STEP Listening Test, he found no significant difference in scores. When he increased word rate gradually, he again found no difference in comprehension as the result of training. Barnard (1970) has reported similar results.

The equivocal results of past attempts to train subjects to comprehend compressed speech are hard to understand. Because of differences in methodology, subject characteristics, and motivational variables in the studies outlined above, determinations of their independent contributions to the comprehension of compressed speech are not possible.

The present experiment was designed to explore the effects of introducing incentives into the training procedure under appropriate control conditions.

OBJECTIVE

The purpose of the present experiment was to discover (1) if soldiers can be trained to understand compressed speech presented at 286 wpm (2.2 times its original spoken speed) and (2) if training methods that provide the listener with incentive motivation can facilitate the comprehension of time-compressed speech.

METHOD

Subjects

The participants were 103 enlisted personnel from Fort Devens, Mass., who had Army General Classification Test (AGCT) scores of at least 110.

Apparatus

An AmBiChron (Koch, 1974) speech-compressor was used to pitch-normalize all speech passages that were played through a variable-speed Crown Model 800 recorder during daily training for the experimental groups.[1] These two machines also were used to record all speech passages given to the normal and fast control groups during their daily training as well as passages given to control and experimental groups during the criterion test.

The listening material used during training and criterion testing consisted of passages taken from The Proud Tower, a nonfiction, Library of Congress Talking Book by Barbara Tuchman (1972). Participants in experimental and control groups listened to speech passages through earphones and were able to control the loudness individually.

A response panel used in the experimental groups had two digital counters, six push buttons, and six red lights. One digital counter recorded points that a participant gained or lost, and the other recorded the number of incorrect responses made on the multiple-choice questions given at the end of each passage during training. One push

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[1]Commercial designations are given only in the interest of precision of reporting and do not constitute endorsement by the Army or by ARI.

button was used to avoid slow speech, and another push button was used to escape from slow speech once it had begun. The remaining four buttons were used to register answers to the multiple-choice questions given during daily training. Two of the red lights indicated whether an escape or avoidance contingency was in effect; the remaining four lights indicated the number of points the participants accumulated. At the end of each training passage, a Kodak Carousel 35mm slide projector presented multiple-choice questions on a rear projection screen to the experimental groups. A standard electric clock was used to record escape/avoidance latencies during training. The presentation of speech passages, rest periods, and multiple-choice questions during training was automatically controlled by solid-state and electromechanical control equipment. The same daily comprehension tests were given to the normal and fast control groups using printed questionnaires instead of the slide projector. All experimental and control group participants were tested by printed questionnaire on the criterion comprehension test.

Experimental Design

Ten participants were randomly assigned to each of five training methods. All groups listened to the same passages selected from The Proud Tower during five 1-hour daily sessions. Each session was divided into three segments, and subjects answered multiple-choice questions on content after each segment. At the end of the week, all subjects were given a standardized comprehension test. This test was divided into five subtests, each 10 minutes long when played at normal speed. Each of the subtests was presented at one of five speeds: normal speed, 1.5 times normal, 1.85 times normal, 2.2 times normal, or 2.55 times normal. All subjects listened to all five speech rates. Briefly, the five experimental groups differed in the following ways.

Point Acquisition and Leave (PAL) Group. During the daily training sessions, participants were given points that counted toward leave time based on (1) whether they elected to listen to faster-than-normal speech as opposed to slower-than-normal speech during each segment and (2) the number of multiple-choice questions answered correctly at the end of each speech segment. If 60% of the questions were answered correctly, the rate of fast speech for the next segment was increased by 13 words per minute. The speech rate for both faster-than-normal and slower-than-normal listening options was controlled by the experimenter. Participants were given immediate feedback regarding accuracy on each of the multiple-choice questions.

Point Loss Avoidance and Leave (PLAL) Group. At the beginning of the first speech segment, subjects were given the maximum amount of points counting toward leave time. Subjects in this group lost points if they (1) failed to elect to listen to compressed speech and (2) failed to answer questions correctly on the multiple-choice test at the end of each speech segment. If 60% of the multiple-choice questions were answered correctly, the rate of fast speech for the next segment was

increased by 13 words per minute. As in the PAL group, the experimenter controlled speech rates, and participants were given immediate feedback regarding accuracy on each of the multiple-choice questions.

Point Acquisition and No Leave (PANL) Group. This group was treated the same way as was the PAL group except that no leave time could be earned by accumulating points.

Fast Control (FC) Group. Subjects in this group listened to the same passages as the other groups over the same period. All speech passages were presented at 2.2 times the normal rate (286 wpm). No points were given and no leave was earned.

Normal Control (NC) Group. Subjects in this group listened to the same passages as all other groups over the same time period. All speech passages were presented at the normal rate. Again, no points or leave time was given.

After all daily training sessions were completed, subjects were given the standardized criterion test for comprehension. The leave time earned by subjects in the PAL and PLAL groups was not affected by their performance on the criterion test.

Criterion Control (CC) Group. Performance of each of the experimental groups on the comprehension test was compared with the performance of the Criterion Control group, a standardization group of 53 Army subjects drawn from the same population of soldiers as the experimental participants. The standardization group had no prior training and listened only to the criterion passages at normal speed on the criterion test.

Procedure

Day 1. All participants in the PAL, PLAL, and PANL experimental groups were presented three 10-minute (when played at normal speed) segments of speech, each followed by five multiple-choice questions on content. A slide projector was used to flash questions onto a screen in front of the participant. The participant had 60 seconds to answer each question. The response was made by pushing one of the four buttons that corresponded to the answer. The response was manually recorded by the experimenter. Depending on the participant's response, points were either added to or subtracted from the counter on the response panel directly in front of the participant.

The first 10-minute segment was presented at normal speed (130 wpm). After answering five questions on this speech segment, the subjects were informed that they would be listening to a period of slower-than-normal speech. The subjects then listened to a segment of speech

presented at 78 wpm, or 60% of the normal rate. After completing the five-question multiple-choice test on this segment, the subjects were told that the next passage would be played at a faster speed than the preceding segment. This segment was followed by another 10-minute segment of normal speech.

Subjects in the NC group listened to three passages of speech played at normal speed. The FC group listened to those same passages at 2.2 times the normal rate. After each segment, subjects in both groups recorded written answers to 10 printed multiple-choice questions.

Day 2 through Day 5. The subjects in the PAL, PLAL, and PANL groups were told that a period of slow speech (78 wpm) was about to begin when a light came on above the right information access key, and that if they wanted to hear faster speech at any time during this period they were to press the information-access key until the light went out. (This key was wired to a dimmer so that each press made the light progressively dimmer until the final press put it out completely.) After completing this series of presses, the subjects were presented with faster-than-normal speech for the rest of the passage. Participants in PAL and PANL groups gained the maximum amount of points if they chose the faster speech within the first 20 seconds of the slow-speech period. Subjects in the PLAL group who waited longer than 20 seconds before turning on faster speech lost points, which could not be retrieved. At the end of each speech period, all experimental groups were given 10 multiple-choice questions about the material they had just listened to.

After this testing period, the subjects were given a 3-minute rest period, during which they were required to remain at their consoles. After this period, they were given the following message:

> In a minute a tone will go on. If you do not wish to listen to any slow speech, press the information-access button labeled "avoid" until the tone goes off. If you do this, no slow speech will be presented and you will be permitted to listen to faster speech for the entire period. If, however, you fail to turn off the tone within 10 seconds, a light will go on and slow speech will start. Then if you wish to turn off the slow speech and listen to faster speech you may do so by pressing the information access button labeled "escape" until the light goes out. If you choose to listen to faster speech, you will avoid the loss of points (PLAL) or gain points (PAL, PANL). The number of points you keep will also depend upon how many questions you can answer correctly at the end of each period of speech.

If the subjects avoided the slow speech or turned the slow speech off after it had begun, they had to listen to compressed speech for the remainder of the passage.

On Days 2 through 5, subjects in the NC and FC groups listened to the same speech passages as the experimental groups. The NC group heard all passages at the normal rate, and the FC group listened to them at 2.2 times the normal rate (286 wpm). At the end of each passage, both groups were given the same multiple-choice questions that the experimental groups received. NC and FC groups, however, received a printed questionnaire to complete.

Point System. The point system was based on an attempt to accumulate or maintain a 720-point total. On each of the 4 experimental days spent in pursuit of this goal, a maximum of one-quarter (180) of the total points could be earned or lost. For each choice to listen to the faster speech within each session's 20-minute information block, 60 points (appearing on the digital counter on the participant's response panel at the rate of 3 points per minute) were accumulated automatically for participants in the PAL and PANL groups or lost automatically in the PLAL group. If all 10 multiple-choice questions for each passage were answered correctly, the point totals remained the same as at the end of the speech passage. For each wrong answer, 5 points were subtracted from accumulated total. When 180 points had been accumulated, the lowest light in a column of four lights went on, indicating that one-quarter of the maximum amount of possible points had been earned. When another 180 points had been accumulated for answering questions correctly on three other information blocks, the second light in the hierarchy went on, indicating that one-half the total points had been earned; and so on until the full number of points had been earned. Conversely, the sessions for the PLAL group started with all four lights on and 720 points on the counter; one light was turned off for each 180 points lost.

Criterion Comprehension Test. Upon completion of the training period on Day 5, all training experimental and control groups (PAL, PLAL, PANL, NC, and FC) were given a 5-minute rest period followed by the criterion comprehension test. The CC group was given the same test with no previous training or exposure to compressed speech. The criterion test consisted of five 10-minute (when played at normal speed) speech passages which were played at each of five speeds: 130 wpm (normal), 195 wpm, 241 wpm, 286 wpm, or 332 wpm. With the exception of the CC group, all subjects listened to all passages played at all speech rates. The CC group listened to all passages at normal speed. The order of presentation of the passages and speech rates was partially counterbalanced. All groups heard all speech passages through earphones, and subjects could manually adjust the loudness.

Response Measures. The mean comprehension scores earned on the criterion comprehension test served as a response measure for all six groups. During daily training, comprehension scores were recorded for the PAL, PLAL, PANL, NC, and FC groups. Total points earned, final speech rates attained, and slow-speech avoidance escape latencies served as additional response measures for the PAL, PLAL, and PANL groups.

It should be noted that one participant in the PAL group and two participants in the NC group left the experiment because of illness. However, only the criterion test data are missing for one of the participants lost from the NC group; the participant's daily performance data were not lost and are included in the analysis of daily performance.

RESULTS

Criterion Performance Data

Table 1 shows the mean comprehension scores for all experimental and control groups for each of the five speech rates given during the criterion testing session on Day 5. Clear differences in performance did not emerge until speech passages were played at 286 wpm (2.2 times the normal rate). At this point, a relatively large decrement in performance is readily apparent in the PANL, FC, and NC groups when compared to the CC group. Although the performance of the PAL and PLAL groups is somewhat attenuated, the differences are not nearly so great as those in the other three groups. At 332 wpm (2.55 times the normal rate), the performance of all five groups is markedly depressed when compared with the CC group.

Table 1

Mean Comprehension Scores on the ARI Criterion Test for All Experimental and Control Groups at Each of the Five Criterion Test Speech Rates

Groups (N)	Criterion Test Speed Rates in wpm				
	130	195	241	286	332
PAL (9)	6.8	6.8	6.0	4.7	3.6
PLAL (10)	6.1	6.5	5.0	4.7	3.3
PANL (10)	5.6	5.1	3.8	3.7	3.2
FC (10)	6.0	5.9	5.4	3.7	3.6
NC (8)	4.6	5.0	5.1	3.6	3.0
CC (53)	5.6[a]	6.0[a]	5.7[a]	6.2[a]	6.2[a]

[a]All tests for group CC were given at the normal speech rate of 130 wpm.

A two-way unweighted means analysis of variance (groups x speech rate) was performed for the comprehension score data obtained during criterion testing; the results are shown in Table 2. The main effects for speech rate as well as the groups x speech rate interaction were significant ($F(4, 376) = 19.76$, $p < .001$; and $F(20, 376) = 1.84$, $p < .05$, respectively). However, the main effect for groups was not significant ($F(5, 94) = 1.95$, $p < .05$).

Table 2

Analysis of Variance Summary Table for the Comprehension Scores for All Groups Across All Criterion Test Speech Rates

Source	SS	df	MS	F
Between subjects				
Groups (G)	122.27	5	24.45	1.95
$Error_b$	1180.2	94	12.56	
Within subjects				
Speech rates (S)	205.18	4	51.29	19.76**
G x S	95.34	20	4.77	1.84*
$Error_w$	976.02	376	2.60	

*$p < .05$
**$p < .001$

Table 3 shows the differences between each of the five experimental and control group means compared with the CC group mean. The numbers in this table were generated by subtracting the CC group mean in each column from each of the experimental means for that column. A positive coefficient for any group indicated that the performance of that group was superior to that of the CC group; negative coefficients are shown where the performance of a group was inferior to that of the CC group.

Table 3

Difference Scores of Each of the Five Experimental and Control Group Means from the Group Mean of the Criterion Control Group

Groups (N)	Criterion Test Speech Rates in wpm				
	130	195	241	286	332
PAL	+1.2	+0.8	+0.3	-1.5	-2.6*
PLAL	+0.5	+0.5	-0.7	-1.5	-2.9**
PANL	0.0	-0.9	-1.9	-2.5	-3.0**
FC	+0.4	-0.1	-0.3	-2.5*	-2.6*
NC	-1.0	-1.0	-0.6	-2.6*	-3.2**

*p < .05
**p < .01

Because the focus of attention in these data was on comparing the performance of experimental and control groups to the performance of the CC group, Dunnett's test was used to analyze the simple main effects for each of the five speech rate changes. The results of this analysis are also shown in Table 3. The difference between means required for statistical significance was 2.31 at $p = .05$ and 2.82 at $p = .01$ ($df = 6, 268$ in each case). Comprehension performance for PANL, FC, and NC groups was significantly poorer than performance of the CC group at 286 wpm (2.2 times the normal rate). However, comprehension performance for the PAL and PLAL groups was not significantly deteriorated until speech rate was 332 wpm, or 2.55 times the normal rate.

Apparently subjects in the two incentive-trained groups, PAL and PLAL, were able to comprehend speech as well at 2.2 times the normal rate as were control group participants (CC group), who listened to the same material at the normal speed. Since this assertion of "no differences" between each of the incentive-trained groups and the CC group is tantamount to arguing for the acceptance of the null hypothesis, the probability of accepting a false null (i.e., Type II error) was assessed using the δ statistic suggested by Winer (1971, p. 26). The authors felt that a true 30% decrement in performance from that of the CC group would represent an important comprehension loss and that any smaller loss had little practical significance. Consequently, the test for Type II error was based on this 30% or 1.86 point decrement in performance. The results of this test indicated that the probability of having committed a Type II error was small ($\delta(9) = 2.86$, $.10 < p < .20$).

Daily Performance Data

Comprehension Tests. Day 1 was a practice and familiarization session for all groups; therefore, only performance data from Days 2 through 5 were analyzed. Because group CC did not receive any daily training, this group was excluded from all analyses of daily performance. Figure 1 shows the mean number of correct answers attained on the daily multiple-choice test probes by each of the five groups averaged over Days 2 through 5.

A three-way analysis of variance (groups x sessions x days) was performed on the mean number of correct answers to the daily multiple-choice questions. This analysis, as shown in Table 4, revealed that the main effects for both groups and sessions were significant ($F(4,43) = 7.47$, $p < .01$; and $F(2,86) = 10.26$, $p < .01$, respectively).

Table 4

Analysis of Variance Summary Table for the Number of Correct Answers to Daily Multiple-Choice Questions

Source	SS	df	MS	F
Between subjects				
Groups (G)	507.46	4	126.87	7.47*
Error	731.64	43	17.01	
Within subjects				
Days (D)	12.70	3	4.23	1.79
D x G	20.51	12	1.71	.72
$Error_1$	305.76	129	2.37	
Sessions (S)	43.90	2	21.95	10.26*
G x S	24.38	8	3.04	1.42
$Error_2$	183.93	86	2.14	
D x S	124.62	6	20.77	10.70*
D x G x S	49.88	24	2.08	1.07
$Error_3$	500.92	258	1.94	

*$p < .01$

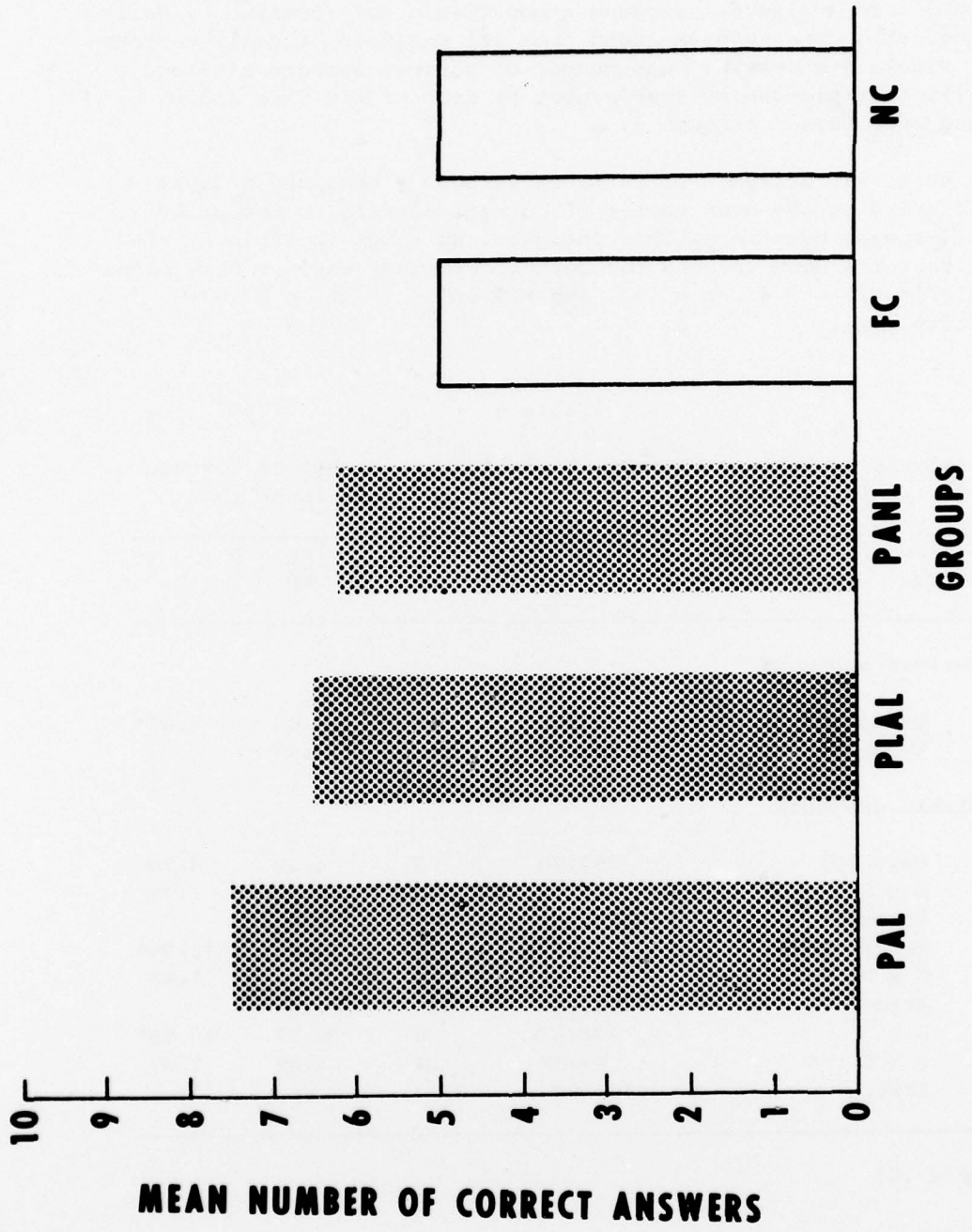

Figure 1. Mean number of correct answers by each group, Days 2 through 5.

The sessions x days interaction was also significant ($F(6, 258) = 10.70$, $p < .01$). No other main effect or interaction was significant. A Tukey Honestly Significant Difference (HSD) test performed on the main effects for groups showed that comprehension scores for the PAL group were significantly higher than those of either the FC or NC groups ($df = 4, 43$, $p < .01$). None of the other main effects was significant. Although all subjects tended to perform better on the session two comprehension test, the significant sessions x days interaction revealed that this tendency was not consistent throughout the training period.

Final Speech Rates. The final speech rates expressed as a percentage of the normal rate (130 wpm) attained by each of the experimental groups (PAL, PLAL, and PANL) are shown in Figure 2. Although the final speech rate attained by the PAL group is clearly superior to that attained by the PANL group, the performance of the PLAL group appears to be only slightly better than that for the PANL group and only slightly poorer than that for the PAL group.

The results of a one-way analysis of variance performed on these data are shown in Table 5. There was a significant difference in final speech rates attained among the three experimental groups ($F(2, 26) = 3.53$, $p < .05$). A Tukey HSD test showed that the final speech rate attained by the PAL group was significantly higher than the rate for the PANL group ($df = 3, 26$, $p < .05$). No other difference among the three groups was significant.

Table 5

Analysis of Variance Summary Table for Final Speech Rates

Source	SS	df	MS	F
Total	1.308	28		
Groups	0.280	2	0.140	3.53*
Error	1.028	26	0.040	

*$p < .05$

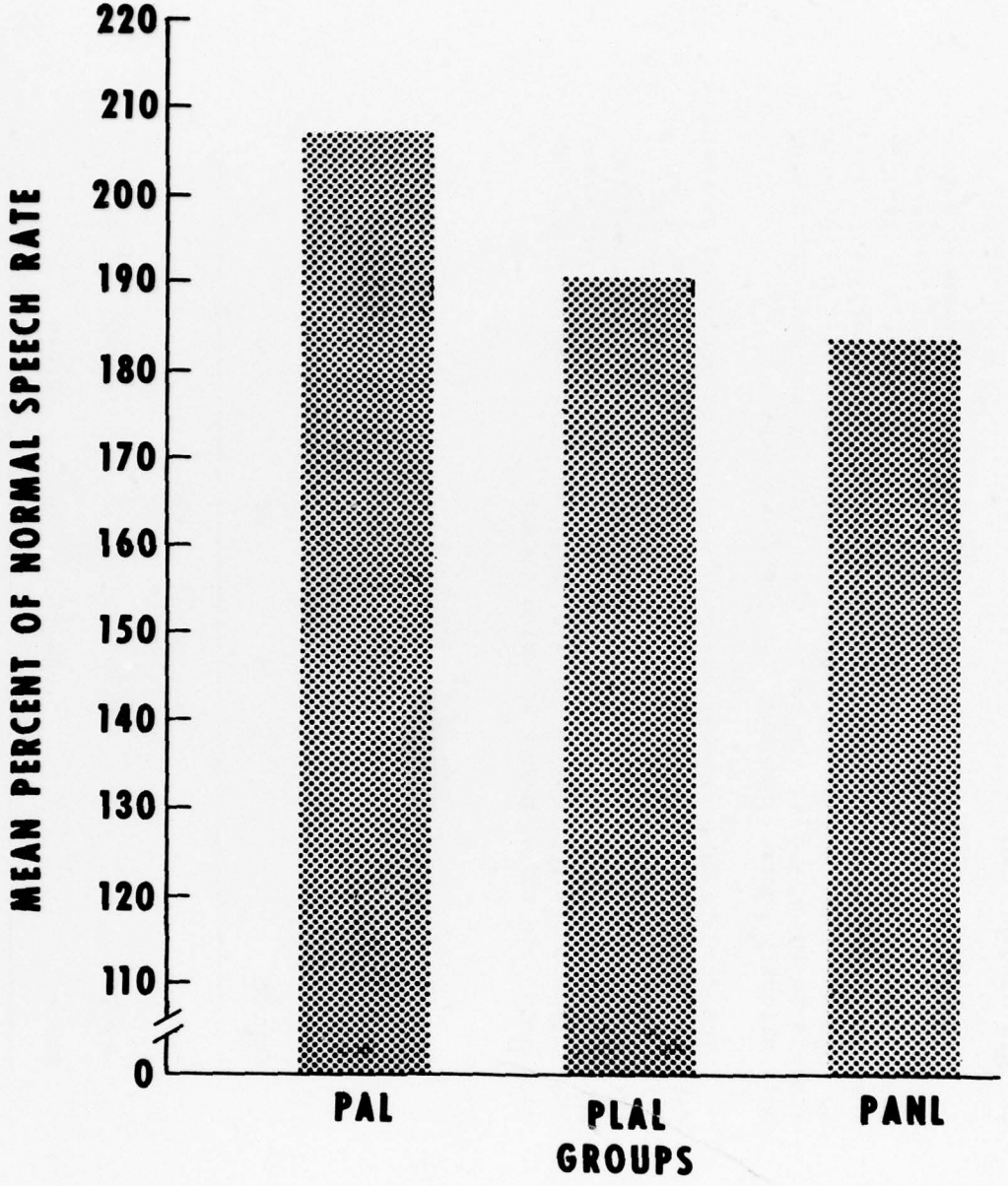

Figure 2. Final speech rates attained by each experimental group.

Total Points Earned. The mean total points of each of the three experimental groups are shown in Figure 3. Once again, the PAL group performance is superior to the PANL group performance. In addition, the performance of the PAL group is much higher than that of the PLAL group. The differences in performance between the PLAL and PANL groups appear to be relatively small.

A one-way analysis of variance performed on these data is shown in Table 6. This analysis revealed a significant difference among the experimental groups with respect to the mean number of points each attained ($F(2, 26) = 5.95$, $p < .01$). A subsequent Tukey HSD test showed that the mean number of points the PAL group earned was significantly higher than the mean number either the PLAL or the PANL groups earned ($df = 2, 26$, $p < .05$). The differences in performance between the PLAL and PANL groups were not significant, however. In interpreting these results, note that the total-points measure represents a combined measure that is dependent on both final speech rate attained and daily comprehension test performance.

Table 6

Analysis of Variance Summary Table for Total Points Earned

Source	SS	df	MS	F
Total	96984.00	28		
Groups	30458.51	2	15229.26	5.95*
Error	66525.49	26	2558.67	

*$p < .01$

Response Latencies. Analysis of the latency to escape or avoid slow speech showed no significant differences among the three experimental groups. A three-way analysis of variance (experimental groups x sessions x days) was performed on the latency data. This analysis revealed significant effects for sessions ($F(2, 52) = 4.93$, $p < .05$), days ($F(3, 78) = 12.76$, $p < .01$), and for the sessions x days interaction ($F(6, 156) = 3.41$, $p < .01$). Because none of the significant main effects or interactions involved the experimental groups, no analyses of simple effects were performed. These results show that response latency was not significantly affected by the various incentive manipulations used with the three experimental groups.

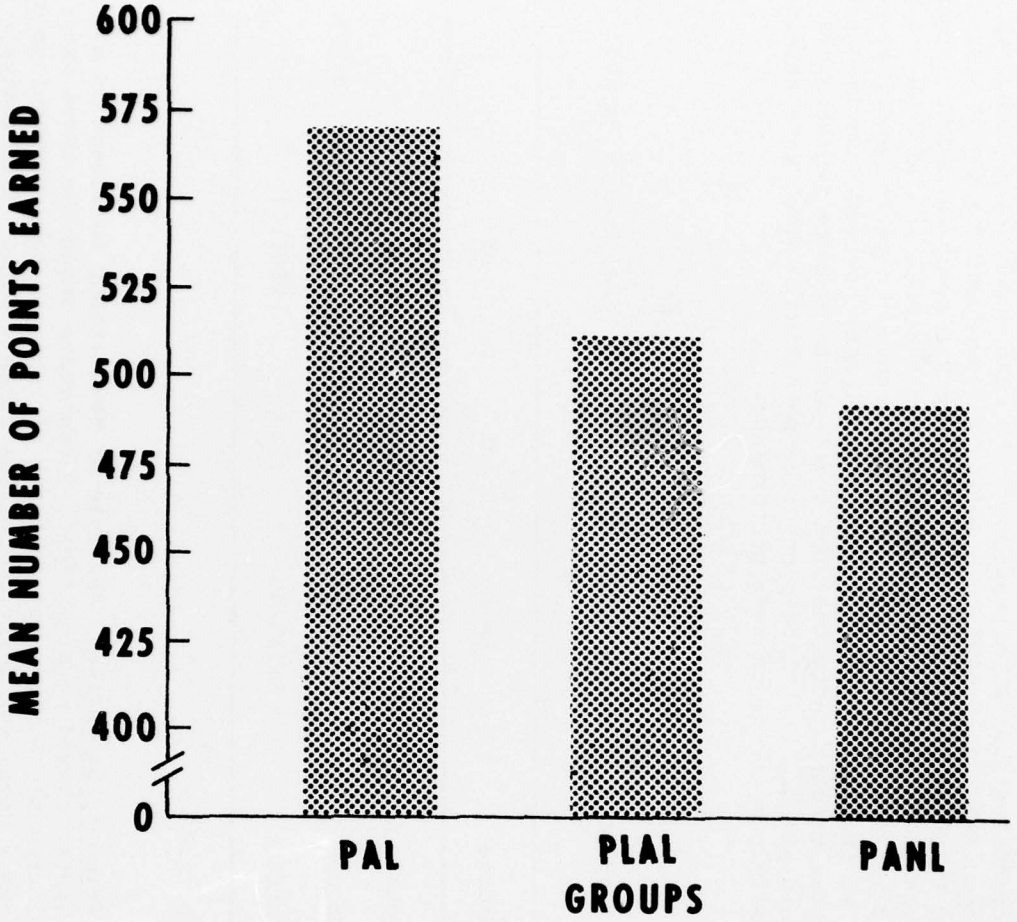

Figure 3. Mean number of points earned by each experimental group.

CONCLUSIONS

This experiment found that soldiers receiving incentives comprehended speech played at 286 wpm (2.2 times faster than normal) without deterioration of performance on the criterion test; whereas performance of soldiers trained without incentives had significantly deteriorated when compressed speech was presented at rates faster than 241 wpm on the criterion test. The nonincentive groups included (1) NC, a group that merely listened to speech segments at normal rates for 1 week with no knowledge of their performance on the daily probes; (2) FC, a group that listened to compressed speech at 2.2 times normal speed with no knowledge of performance; and (3) PANL, a group that received immediate knowledge of results on each of the daily test probes as well as performance-dependent increases in compressed speech rates. The only difference between the PANL group and the PAL group was the lack of opportunity to earn leave time. For this population, the results indicate that merely giving feedback about performance is not sufficient to insure good performance.

It is instructive to compare the present data with those reported by Foulke (1968) on listening comprehension as a function of word rate for untrained listeners. Foulke found that the comprehension scores of college students untrained in listening to compressed speech did not significantly decline until word rate was increased above 250 wpm. Foulke's results are similar to those obtained for the nonincentive groups (PANL, FC, and NC) in the present study. The comprehension scores in this study declined at about the same number of words per minute (i.e., above 241) as scores in Foulke's study. The performance of those trained using incentive methods (PAL and PLAL) did not drop off until the groups were presented with rates faster than 286 wpm.

The results show that the incentive training methods used in this experiment were effective in producing short-term, positive changes in performance. However, the long-term effects of incentive training need to be assessed before these techniques are applied.

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